MINERALOGY OF SEDIMENTS
IN
MAHENDRA TANAYA RIVER BASIN
ORISSA — ANDHRA PRADESH

A Thesis Submitted
in Partial Fulfilment of the Requirements
for the Degree of
MASTER OF TECHNOLOGY

By

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to the

DEPARTMENT OF CIVIL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY KANPUR

OCTOBER 1982

CERTIFICATE

This is to certify that the present work titled, 'Mineralogy of Sediments in Mahendra Tanaya River Basi Orissa - Andhra Pradesh', has been carried out by Shri P.V. Ramana Murty under our supervision and the same has not been submitted elsewhere for a degree.

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ABSTRACT

The Mahendra Tanaya river originates in the hills of Mahendra giri in the Orissa state, and joins in Andhra Pradesh. The present study is based on field and laboratory investigations of samples collected from 10 locations along the 37 km river course. A geological map of the area has been prepared from LANDSAT imageries and this data is confirmed by spot checks in the field. The hilly area, upper part of the basin consists of khondalites, charnockites, leptynites and granite gneisses. At some places laterite capping is noticed on khondalites. The lower part of the basin has no exposure of rocks and is covered by river sediments.

The heavy mineral analysis reveal the dominent presence of sillimanite, garnet, hypersthene and this could be very well correlated with the source rock mineralogy. The stable minerals like zircon, rutile and ilmenite are present in all the samples. Monazite is present in the confluence of the river to the sea. In the upper part of the basin, close to the source of the river, the clay minerals are kaolinite and montmorillonite. Near Tumbakota,

in the central part of the basin, the presence of kaolinite, illite and montmorillonite is observed. However in the confluence of the river to the sea the absence of montmorillonite and kaolinite and the presence of illite and chlorite is noticed. Variation of relative abundance of clay minerals are also calculated by considering the peak height-ratios of kaolinite and illite. This can be explained by uptake of potassium and other cations by clay minerals.

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CHAPTER I

INTRODUCTION AND OBJECTIVE

1.1 Introduction

Erosion of land by river action is one of the most fundamental process on the surface of the earth. Various aspects of this process has found application in classical geology, soil mechanics, flood control and water resources engineering, geo-chemistry and environmental engineering. It is generally accepted that land erosion has two parts: mechanical erosion resulting in the bed load and the suspended load of rivers and chemical erosion which controls the chemical load or water quality.

Recent work on fundamentals of erosion has also established that there is a genetic relationship between mechanical and chemical erosion, through the rock type of the drainage basin. For example, while chemical erosion causes decomposition of rocks giving dissolved chemicals it simultaneously supplies the time grained clay minerals carried in suspension. The nature and concentration of chemicals and the type of clay minerals ultimately depend on the type of rock that was subjected to erosion.

The development in study of river erosion has made it possible to undertake field-cum-laboratory projects on

selected river basins where the mineralogy of sediments and water quality of rivers can be interpreted in terms of the composition of parent rocks in the drainage basin. Some important investigations of this type are reviewed below.

1.2 Previous Work

Garrels and his co-workers have done poineering work to establish the chemical frame work of weathering reactions. In the most simplified, weathering of rock-forming silicate minerals can be represented as

$$\text{ROCK} + CO_2 + H_2O = \text{Clay} + \text{Cations} + SiO_2 + HCO_3$$

The CO_2 in this reaction comes from the atmosphere demonstrating the control of rock-water-atmosphere reactions. Various studies have shown that kaolinite and montmorillonite are typical rock-derived clays which are carried in suspension into the sea. At the river mouth, there is a possibility of the degraded silicates picking up ions like K^+ from sea water and the above reaction being partially reversed, in the clays changing into illite.

Raymahashay (1971), studied this process at the Burhabalang river mouth on the Orissa coast. He concluded that kaolinite in river sediments are converted to illite by reactions with sea water. The SiO_2 content decreases

and Cl increases from fresh river water towards the estuary.

Rao (1979), reported the clay mineralogy of sedimentary rocks in the Godavari basin in terms of weathering environment during the time of deposition. He reported the presence of montmorillonite, kaolinite and illite in these rocks. The proportion of kaolinite is dominant in non-marine (river deposited) rocks where as montmorillonite and illite increases in marine rocks.

Subramanian (1979), studied the suspended sediments in various rivers of India including Godavari. The main minerals in the suspended sediments are chlorite, illite, kaolinite, montmorillonite together with quartz and feldspar. In the Godavari basin, the sediment load represents mechanical weathering is about 7 times that of the chemical load (Bikshmaiah and Subramanian, 1981).

Oceanographic surveys have also established the mineralogy of the submarine cones (fans) built up near the mouths of the major rivers of India.

Mallik (1978), reported illite, chlorite and kaolinite in the Ganges cone and illite with montmorillonite in the Indus cone. The presence of montmorillonite and mixed layer clays is usually traced to weathering of basic igneous rocks like the Deccan basalts.

These are some representative studies from India particularly in rivers draining in to the Bay of Bengal. This discussion is particularly relevant to the present study of Mahendra Tanaya **river** basin on the East coast.

1.3 Objective of Present Work

Literature review revealed that systematic studies of erosion in river basins are rare in India. With the back ground models discussed above, it was decided to select a middle-order drainage basin which has variation in rock type and to attempt a correlation of river sediments with weathering process. The Mahendra Tanaya river basin in Orissa - Andhra Pradesh was considered to be suitable for this purpose. The following plans of work was proposed.

(1) Confirmation of the geology of the drainage basin through study of geologic maps and LANDSAT satellite imageries followed by spot checks in the field.

(2) Systematic sampling of the river sediments for the entire 37 km course from source to mouth. Separation of the clay fractions for characterization by X-ray diffraction, Differential thermal analysis and Electron microscopy.

(3) Study of the heavy mineral fraction of the same samples taken at regular interval from source to mouth and identification by Optical microscopy and X-ray diffraction.

(4) Preparation of variation diagrams for clay minerals and heavy minerals and interpretation in terms of weathering and erosion of source rock.

(5) Interpretation of mineral-water reactions in terms of broad variations in river water quality.

CHAPTER II

METHOD OF WORK

2.1 Methodology and Sample Preparation

To know the detailed mineralogy, organic matter and chemical characters of the river Mahendra Tanaya suspended river sediment samples were collected at a regular distance and time intervals. The exact locations for the soil sediment and water samples are indicated in Fig. 2.1 and Table 2.1.

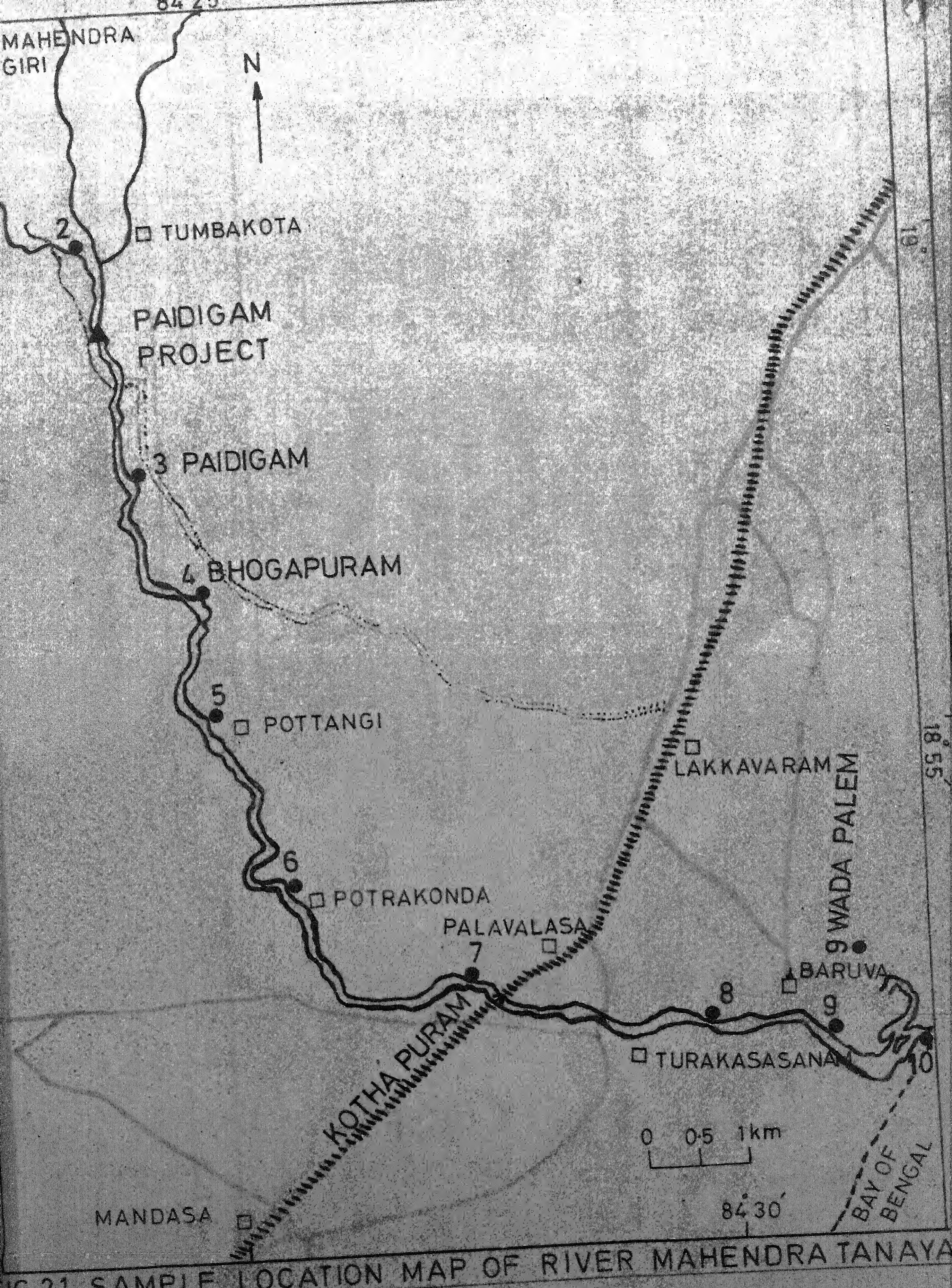
The clay fractions and the heavy mineral separations have been carried out on the basis of conventional standard procedures.

In the present work, limited Khondalitic rock samples have been analysed by using X-ray diffractometer.

2.2 Methods

2.21 Heavy mineral separation:

The samples were washed with water and dried in an oven at constant temperature (105°C). Bromoform was used, as the medium to separate the heavy minerals from the soils so that the light minerals ($<$ 2.87) are floated up and the heavy minerals ($>$ 2.87) are settled down. The heavy minerals separated on filteration are mounted on glass slides.

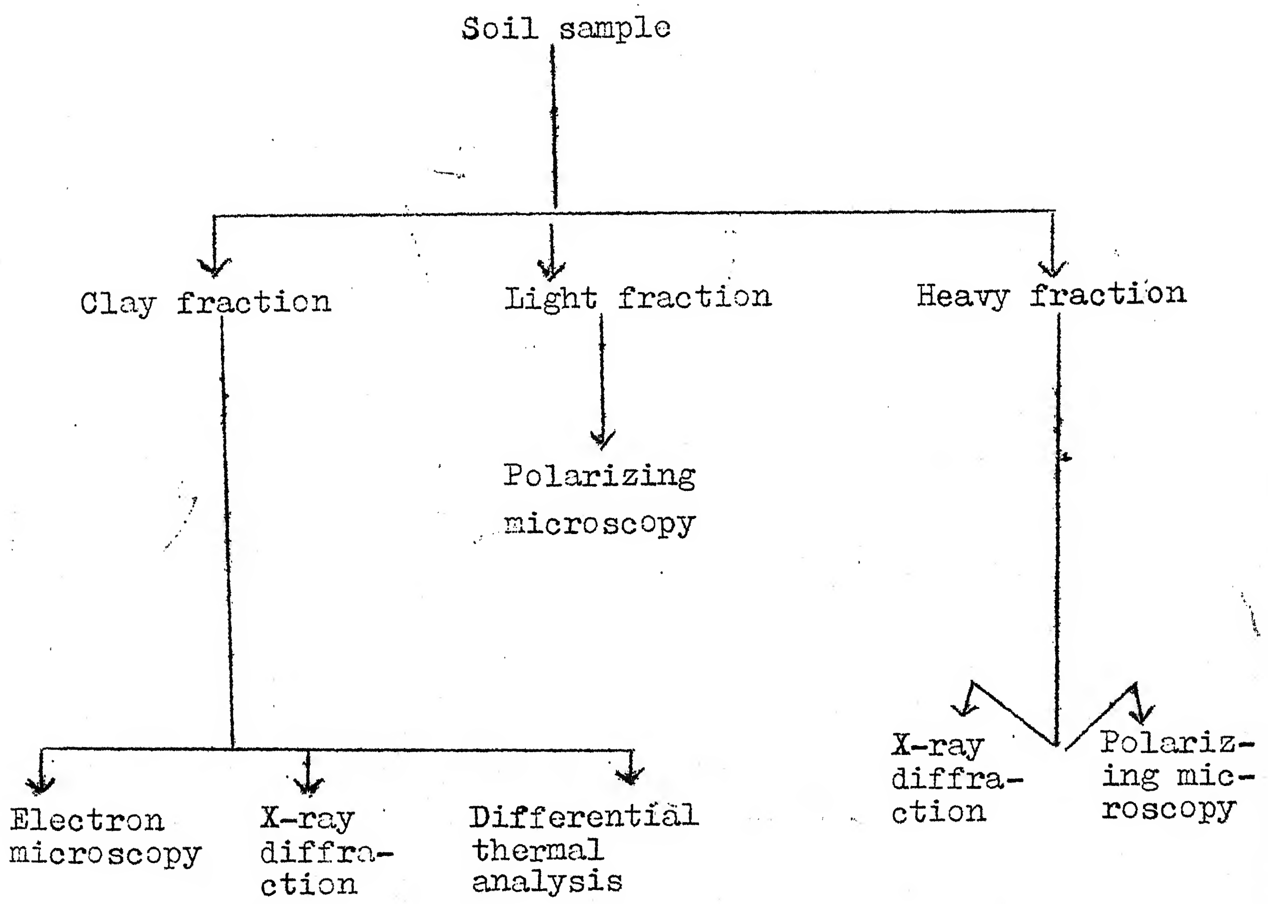


FIG·2.1 SAMPLE LOCATION MAP OF RIVER MAHENDRA TANAYA

TABLE 2.1 DESCRIPTION OF SAMPLES OVER THE MAHENDRA TANAYA RIVER BASIN

Sl. No.	Sample Numbers			Near by location	Lattitude	Latitude	Distance in km from Origin
	Clay	Water	Heavies				
1	CS1	WS1	HS1	Eastern Ghats	84°19'2''	19°2'55''	0.0
2	CS2	WS2	HS2	Tumba Kota	84°20'15''	19°1'22''	4.4
3	CS3	WS3	HS3	Paidigam	84°21'2''	18°58'2''	9.0
4	CS4	WS4	HS4	Bhogapuram	84°23'30''	18°57'21''	12.6
5	CS5	WS5	HS5	Pottangi	84°25'29''	18°54'3''	15.6
6	CS6	WS6	HS6	Patrakonda	84°2' 6''	18°53'20''	21.9
7	CS7	WS7	HS7	Kottapuram	84°27'21''	18°53'2''	25.6
8	CS8	WS8	HS8	Turakasasanam	84°28'	18°53'	30.0
9	CS9	WS9	HS9	Wadapalem	84°30'	18°52'55''	32.9
10	CS10	WS10	HS10	Bay of Bengal (Junction)	84°32'	18°51'30''	37.3

The scheme of analysis for the soil samples is as follows:



The water samples collected during different seasons have been analysed as per the scheme indicated below:

Water sample

pH | Temperature (t^oC) | Specific conductivity (micro-mhos/cm)

2.22 Polarizing microscopy

Heavy minerals are mounted upon glass slides with Canada balsam (n = 1.54) and were studied by Bosch and Lomb polarizing microscope.

2.23 Electron microscopy

The clay samples are suspended in distilled water that is prepared by adding of 20 mg of sodium hexa meta phosphate per 1000 ml distilled water.

The specimens are made by using ultra-sonic vibrator to get it mixed well with the solution, then a drop of dilute ~~i~~solution is air dried on a Carbon film supported by a Copper-grid.

Philips EM301 Electron microscope is used in this experiment.

2.24 X-ray diffraction

The samples were grounded to pass through ASTM 200 mesh. About 20 grams of each sample washed with distilled water three to four times to remove any soluble material. The sample in distilled water were dispersed using sodium hexametaphosphate (40 grams in 1000 ml distilled water) and the clay fraction separated by using Strokes law. The Anderson pippette was used to separate the clay size particles. Oriented (001) slides prepared from clay suspension were used for the X-ray analysis.

X-ray diffraction analyses have been carried for these oriented samples using X-ray unit of GEC XRD - 5 operating at 30 KVP and 20 mA with using Ni - filtered Cu Kα radiation. Recording has been carried out at $2^{o}(2\theta)$/min. The X-ray analyses have been carried out not only on the natural oriented fractions but also on the glycolated (with ethylene glycol) and on heated (500^{o}C) samples. The samples were scanned between $5^{o} - 40^{o}(2\theta)$ with a chart speed of 2^{o} per inch.

2.25 Differential thermal analysis

About 100 mg of the sample has been used for analysis with MOM Derivatograph. The heating rate is 10^{o}C/min from

room temperature to $1000^{o}C$.

2.26 Water analysis

The collected waters are measured their pH, temperature ($t^{o}C$) and conductivity.

2.261 pH measurement : Philips precision pH meter is used to measure the pH of the water. Temperature of each of the samples is also recorded at the same time. The measured pH at various temperatures are made converted to $25^{o}C$ by using standard pH - temperature graph.

2.262 Conductivity: The conductivity of the water samples is measured by using Leitfahigkeifsmessn conductivity meter, from the conductivity, TDS of the samples is calculated with multiplying by cell parameter.

CHAPTER III

GEOLOGICAL SET-UP AND WATER QUALITY OF MAHENDRA TANAYA RIVER BASIN

3.1 Regional Geology of Eastern Ghats

The Eastern ghats are tightly folded into isoclinal with occassional synforms and antiforms Vaidyanathan (1978). The area under investigation forms a part of the Eastern ghats terrain. According to Pascoe (1939), the country rocks consists of Khondalite, Charnockite, Garnetiferous leptynites and Granite gneisses. The weathering of the formations has resulted in difficulties in recognizing the boundaries between one and another in the field.

According to Pascoe, a greater degree of weathering has been observed in the finer grain varieties of granite. In general,the granite is garnetiferous. Evidences of intense crushing in the garnetiferous leptynites and charnockites has also been reported.

Prudvi Raju and Vaidyanathan (1978a) has studied aerial photographs of an area of about 2000 sq.km. around Visakhapatnam. It shows that broad structural trends are clear only where there are no laterite caps. The laterite capping show off on higher altitude with light tone and generally across structural trends. The capping

aligned ENE-WSW with a general altitudinal accordance are suggestive of their occurrence over remnants of a single planar surface.

LANDSAT imageries and Aerial photographs were studied by Prudvi Raju and Vaidyanathan (1981), to delineate the fracture patterns of Eastern ghats comprising about 50,000 sq. km. of area and analysing their possible significance. The frequency azimuth rose diagram of fracture patterns indicate two sets of preferred orientations in ENW-WSW and E-W directions. It is possible that some of the fracture traces are relatively much younger than the main Eastern ghat orogeny. These younger fractures may be related to a tectonic movement during mid-tertiaries.

Durga Prasada Rao (1978), in a study on red soils of Bhemilipatnam of Andhra Pradesh has reported the presence of illite, chlorite.

Rao (1979), concluded from studies on Zircon that the red soils in the bad lands are derived from Khondalites under riverine conditions as inferred from sand-silt-clay proportions.

Seshagiri Rao (1980), has reported the presence of halloysite, Kaolinite and also gibbsite within the lateritic soils from Rajahmandry.

A study of logs of more than 100 bores put in the tidal basin and features reported in Visakhapatnam and elsewhere along the coast indicates that during the commencement of holocene (since 10,000 years B.P.),the sea level might have been about 7 metres than the present level before it went down to as low as 25 metres and raising again to the present level (Prudvi Raju and Vaidyanathan, 1978b).

3.2 Geological Set-up of Mahendra Tanaya River Basin

The area under study is described in two parts, the upper part is in the North that is hilly stretch and completely forest covered (Plate 3.1). It has high rain fall, The average rainfall is around 250 cm and the area has a typical humid-tropical climate. The lower part of the river basin with an area of 120 sq. km. around Baruva is located in the S.E. corner. Baruva is well connected with a railway line on the Howrah - Madras route and is 180 kms from Visakhapatnam.

The area under study is confined within Longitude $84^{o}19'22''$ E - $84^{o}32'$E and Latitude $18^{o}51'30''$ N - $19^{o}2'55''$N. Mahendra giri with its altitude of 1475 metres constitute the second highest peak in the Eastern ghats. The river Mahendra Tanaya has its origin in this peak and it drains the Eastern flanks of the Eastern ghats and merges with

Bay of Bengal. Prior to its confluence with the sea, the river runs parallel to the coast for some distance (Plate 3.2). The origin of the river emerges out from a spring (Plate 3.3). Infact, a series of springs have been noticed in the vicinity of its source area (Plate 3.4) which appears to be structurally controlled. The springs are aligned in a line perpendicular to the general trend of Mahendra giri. At the river estuary, thick concentration of heavy minerals is noticed (Plate 3.5).

The major Geomorphological units of the area are hill slope, debris slope, isolated hillocks with bad lands. Near coast sand dunes and red beds are found. The drainage pattern of the river is dendritic. In fact, the stream deposits reveal the mature nature of the river. Hard and resistant inselbergs indicate that the area has almost reached a peneplan.

The Geological sequence in the region (Fig. 3.1) is as follows:

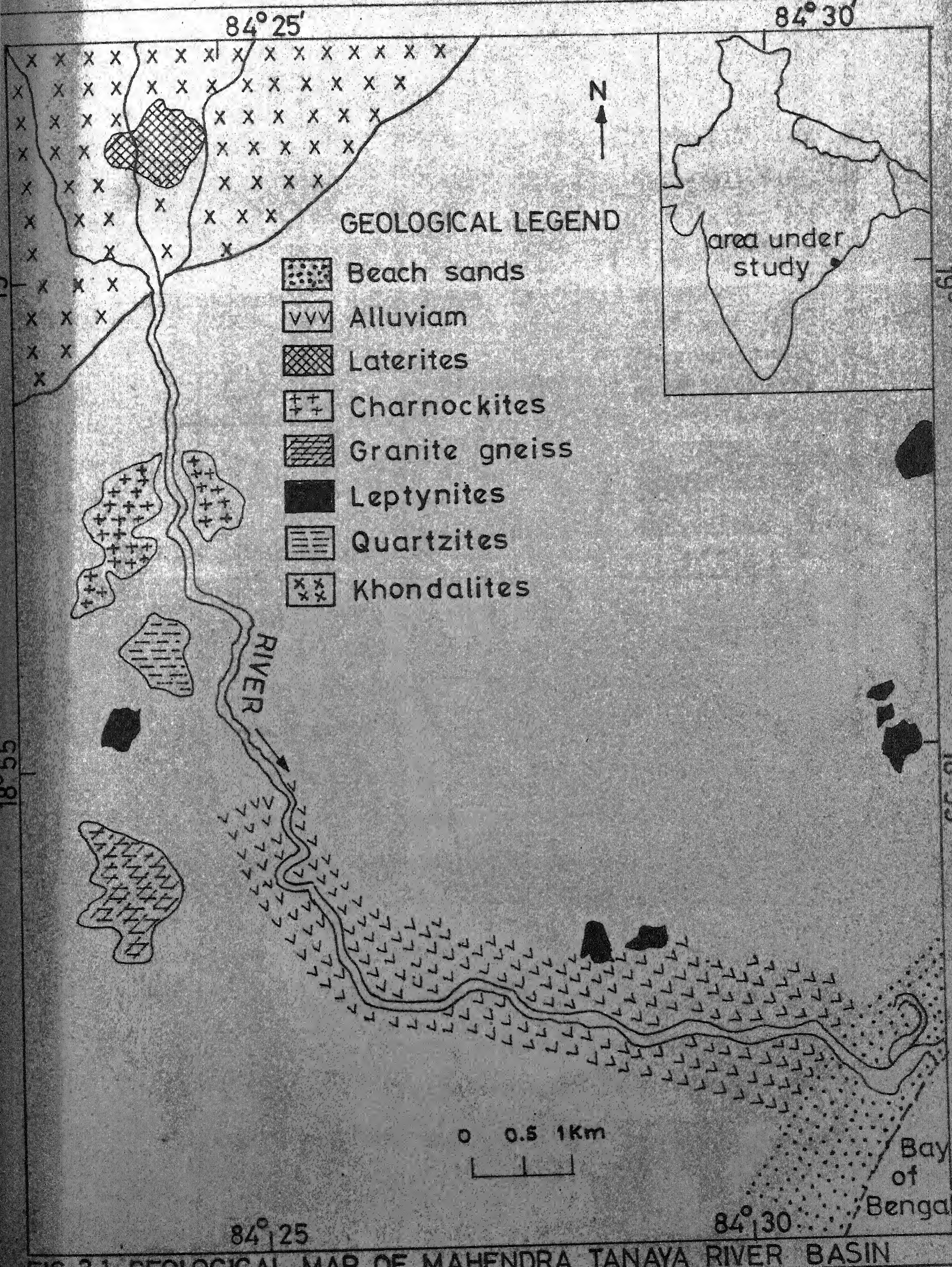


FIG.3.1 GEOLOGICAL MAP OF MAHENDRA TANAYA RIVER BASIN

Recent		Newer Alluvium
		Older Alluvium
Pleistocene		Laterites
Pre-cambrian	Ortho-schists	Charnockites
		granite gneiss
	Para-schists	Leptynites
		Quartzites
		Khondalites

The prevailing strike of foliation in the khondalites is 310°N with dips of 55° to 65° NE. The presence of khondalite xenoliths in the charnockites suggest that the khondalites are older and the charnockites are the intrusive (Permaul, 1975). The lucocratic leptynites are more similar to khondalites in their mineralogical composition.

The charnockites are basic in composition and have been metamorphosed to granulitic facies (Perumal, 1975). Intermediate charnockites have also been reported by Perumal and this group has been thought to be a product

of assimilative reaction between basic magma and the peltic host rocks prior to the on set of metamorphism. The charnockitic group of rocks have been relegated to a geological age of around 2000 m.y(**Sriramadas** and Rao,1979).

The highly weathered khondalites indicate the alteration of plagioclase to the clay minerals resulting in the formation of laterite containing kaolinite, halloysite, gibbsite, and illite minerals (Fig.3.2).

3.3 Water Quality of Mahendra Tanaya River

The samples collected in March, August and November 1981 were analysed for their pH and conductivity. Conductivity values were converted to Total Dissolved Solids (Table 3.2). pH and TDS increasing from source to mouth (Sample 1 to 10) in all seasons. This is obviously due to mixing of sea water in eastuary. In general way, TDS decreases between March and November this may be due to dilution by rain.

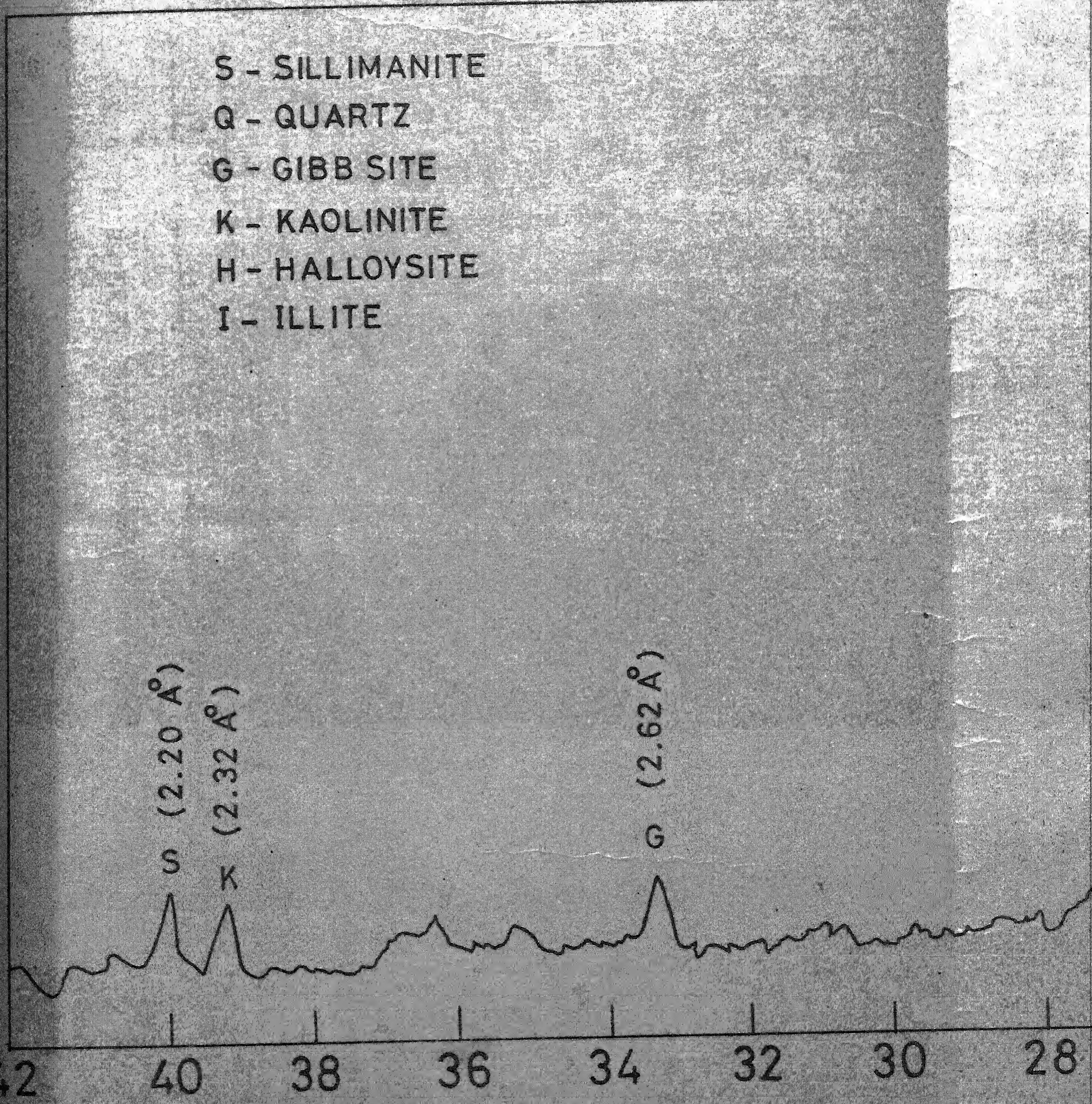
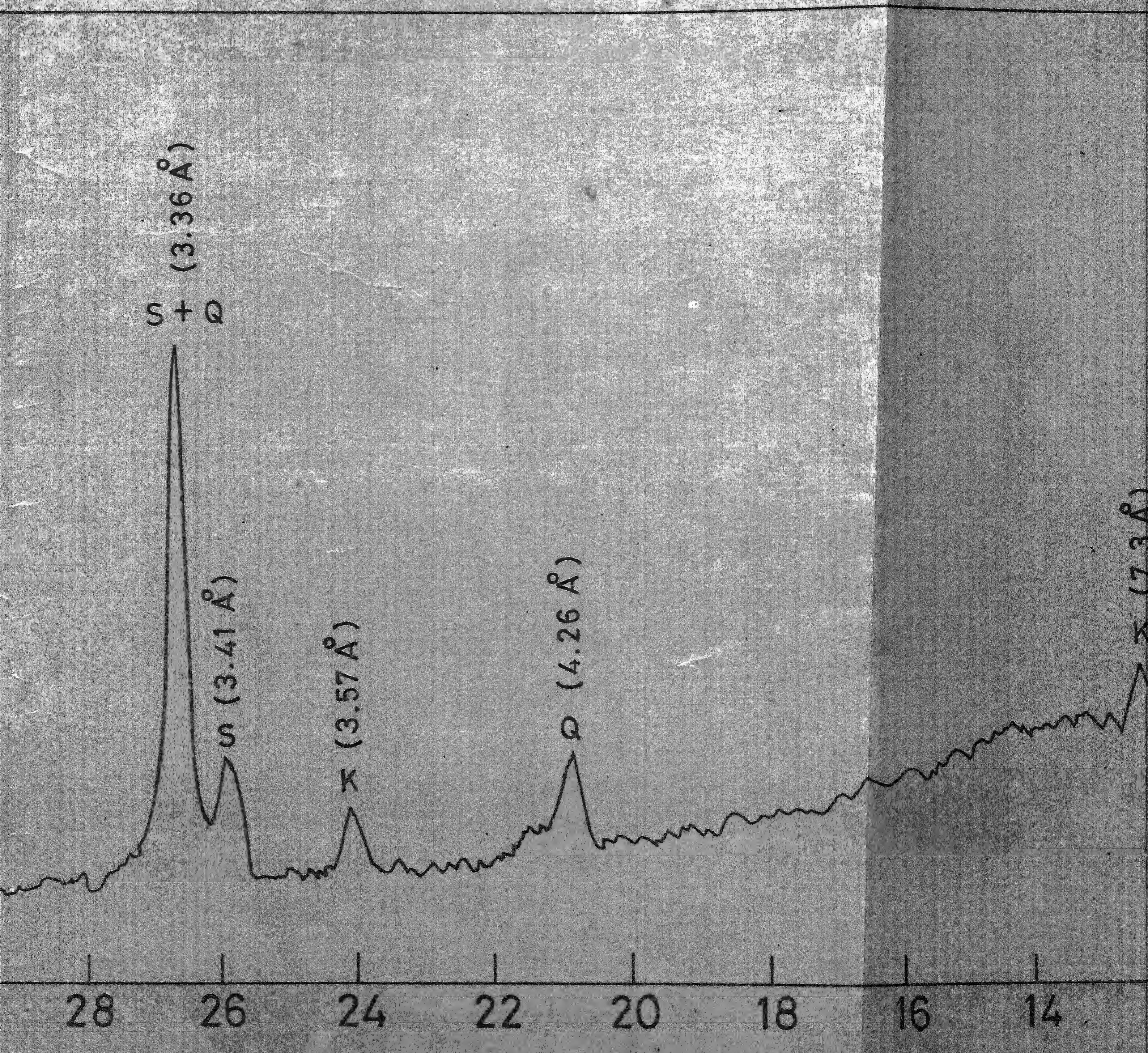
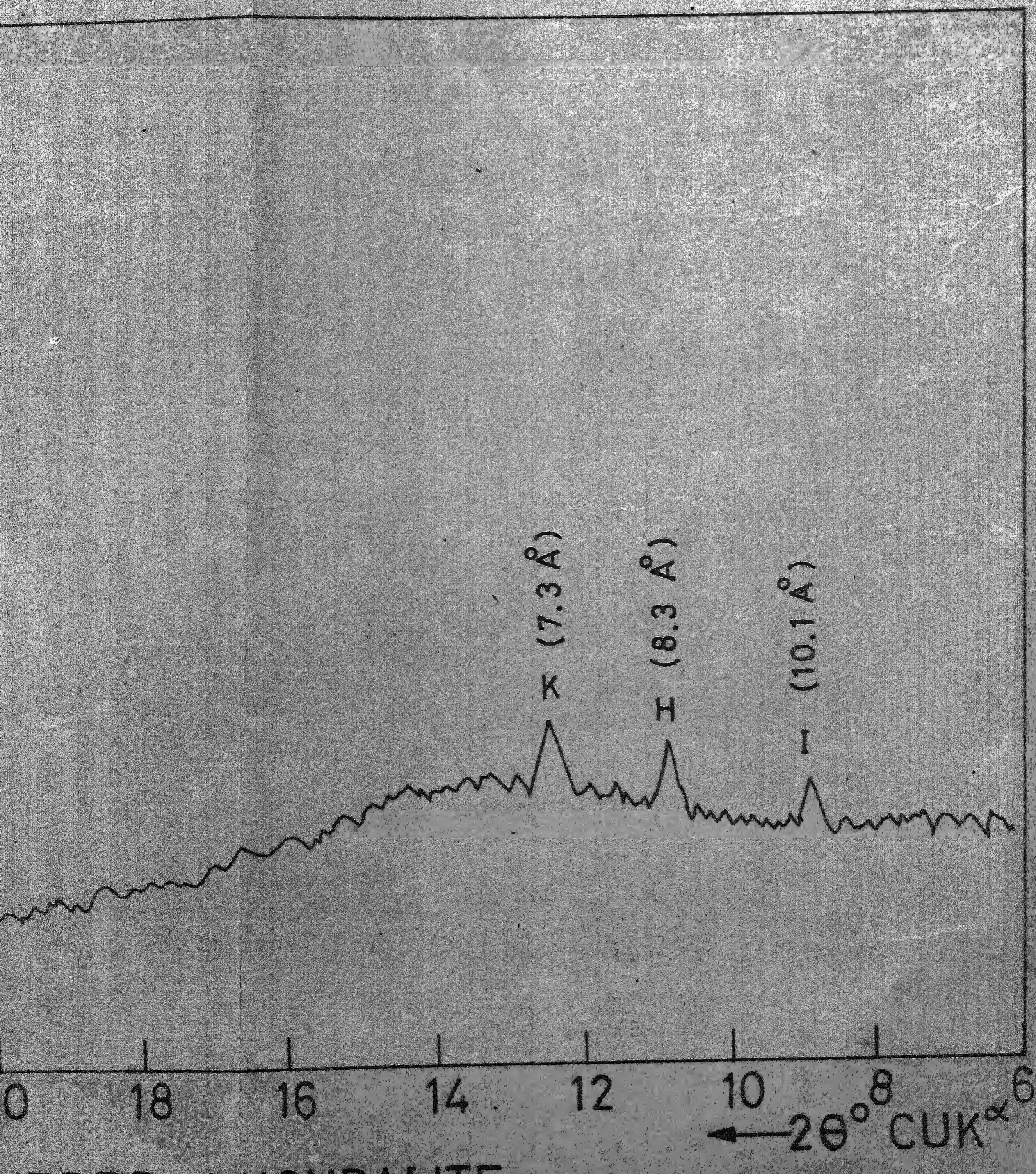


FIG.3.2 X-RAY DIFFRACTION



ACTION PATTERN OF WEATHERED KHONDALITE



HERED KHONDALITE

TABLE 3.2 VARIATION OF pH AND TDS OF MAHENDRA TANAYA RIVER WATERS

Sample No.	March 1981		August 1981		November 1981		Cyclic mean values	
	pH at 25°C	TDS in ppm	pH at 25°C	TDS in ppm	pH at 25°C	TDS in ppm	pH at 25°C	TDS in ppm
1	6.86	279	6.45	188.5	6.95	71	6.7	176
2	7.20	281	6.43	209.2	7.10	89	6.9	193
3	7.16	204	6.45	253.5	6.90	126	6.8	191
4	7.24	349	6.35	308.7	7.10	159	6.9	235
5	7.26	436	6.31	364.0	7.15	250	6.9	350
6	7.49	559	6.32	364.9	7.15	256	6.9	393
7	7.31	563	6.46	508.9	7.20	281	7.0	449
8	7.01	258.7	6.30	142.0	7.35	198	6.9	233
9	7.9	2692	7.41	2307.5	7.95	1320	7.7	2106
10	8.1	3031	7.90	2639.0	8.0	1080	8.0	2350

CHAPTER IV

CLAY MINERAL ANALYSIS

Clay Mineral Analysis of Mahendra Tanaya River Sediments

Clay samples have been collected along the length of the river starting from its source to its confluence into Bay of Bengal. The river basin is divided into two stretches according to their difference in elevation the upper stretch is hilly stretch and the down stretch is plain stretch.

Hill stretch : (Mahendra giri - Patrakonda)

X-ray diffraction patterns of the clay samples are illustrated in Fig. 4.1, 4.2, 4.3 and 4.4. In general, kaolinite, illite, halloysite, montmorillonite and gibbsite have been noticed in all the samples.

Station 1 (CS1): At Mahendra giri kaolinite has been inferred by its characteristic peak around 7.15A^{O}, while illite has been identified from its characteristic peak around 10.1A^{O}. Montmorillonite has been confirmed from the glycolated samples on the basis of shift in the peak from 14.2A^{O} to 17.7A^{O}. The appearence of 4.85A^{O} peak indicates the presence of gibbsite. Relative peak intensities indicate the dominance of Kaolinite, montmorillonite and gibbsite.

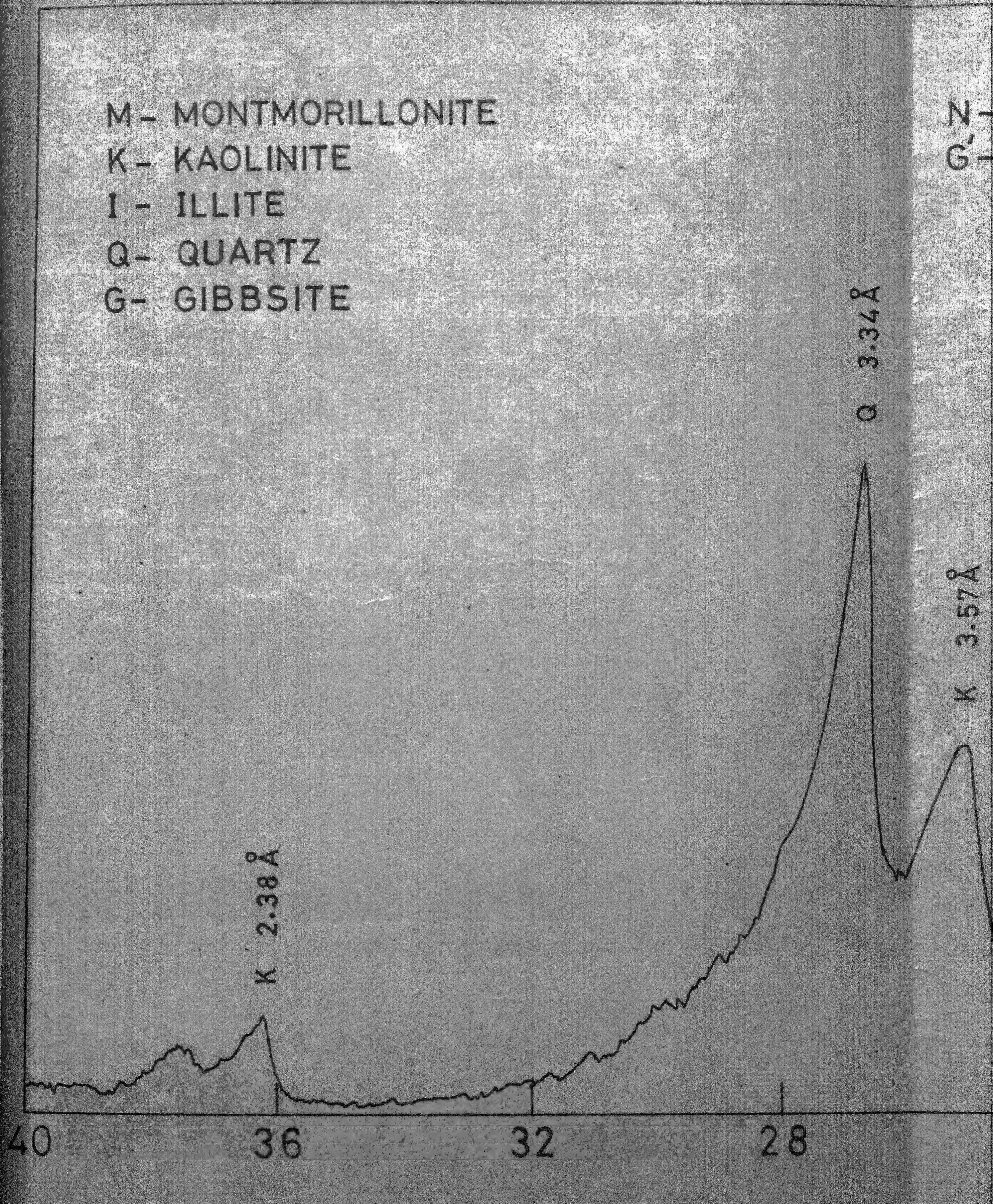
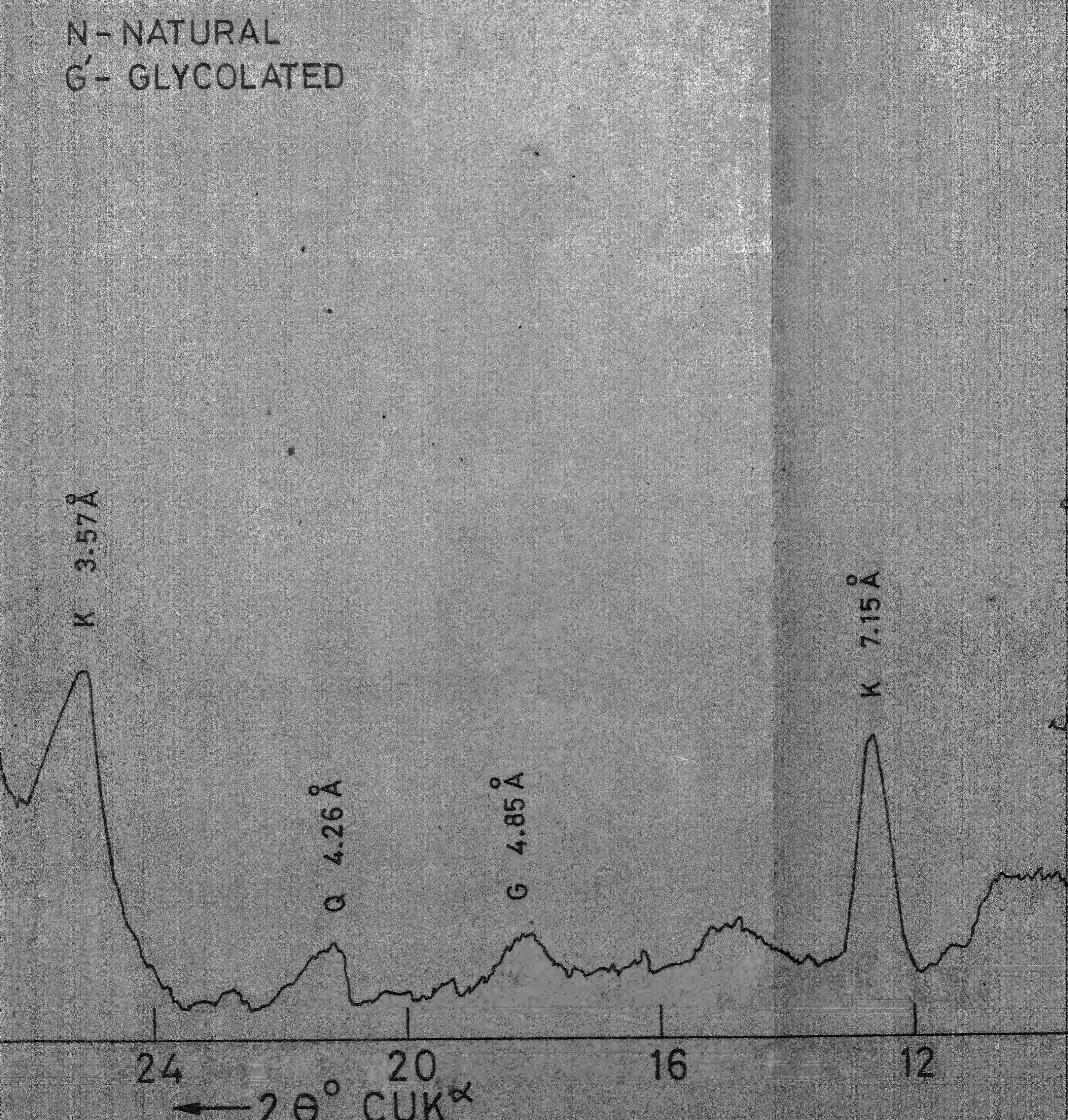
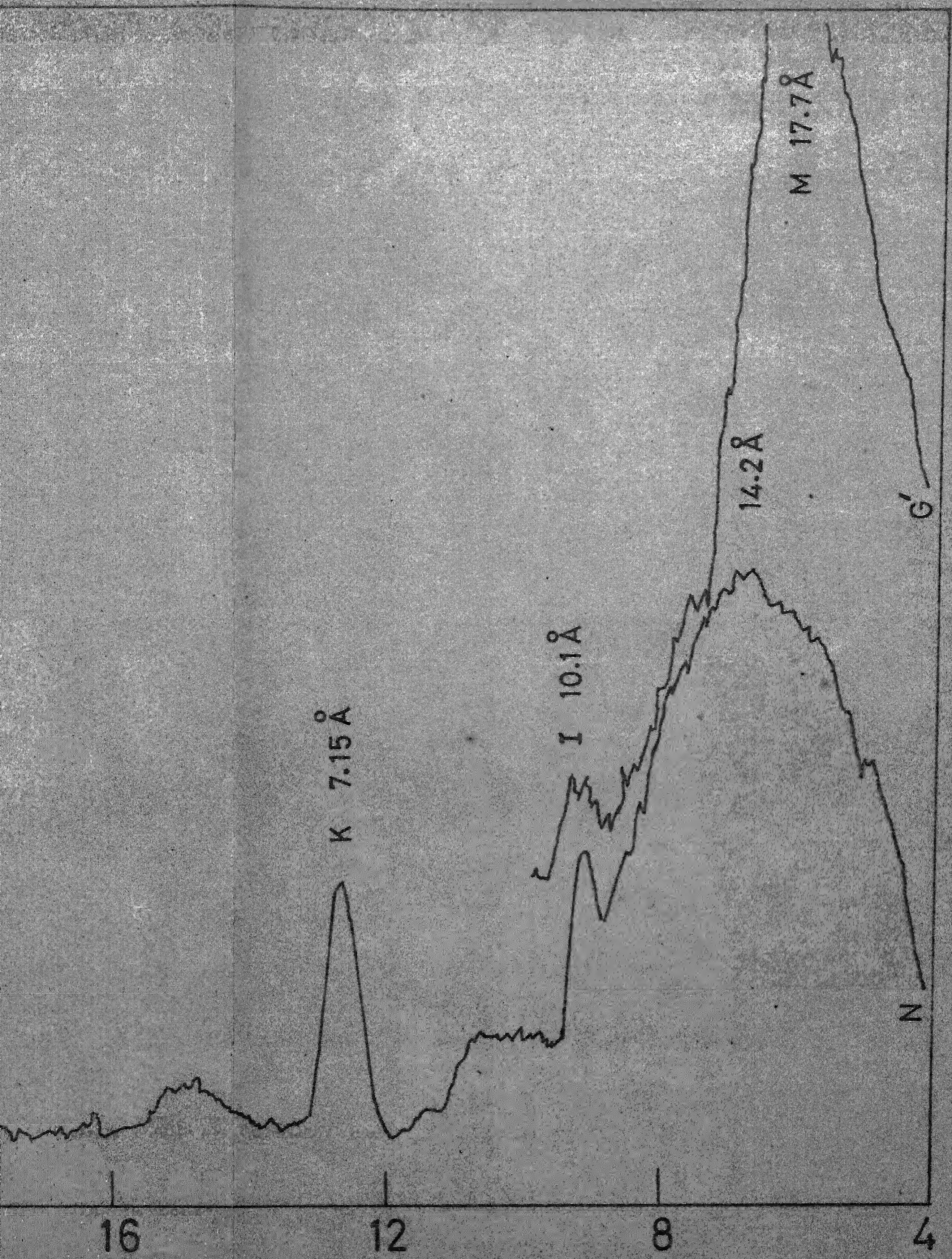


FIG. 4.1 X-RAY DIFFRACTION PATTERNS



TTERNS OF MAHEDRA TANAYA RIVER SEDIMENTS (CS



A RIVER SEDIMENTS (CS1)

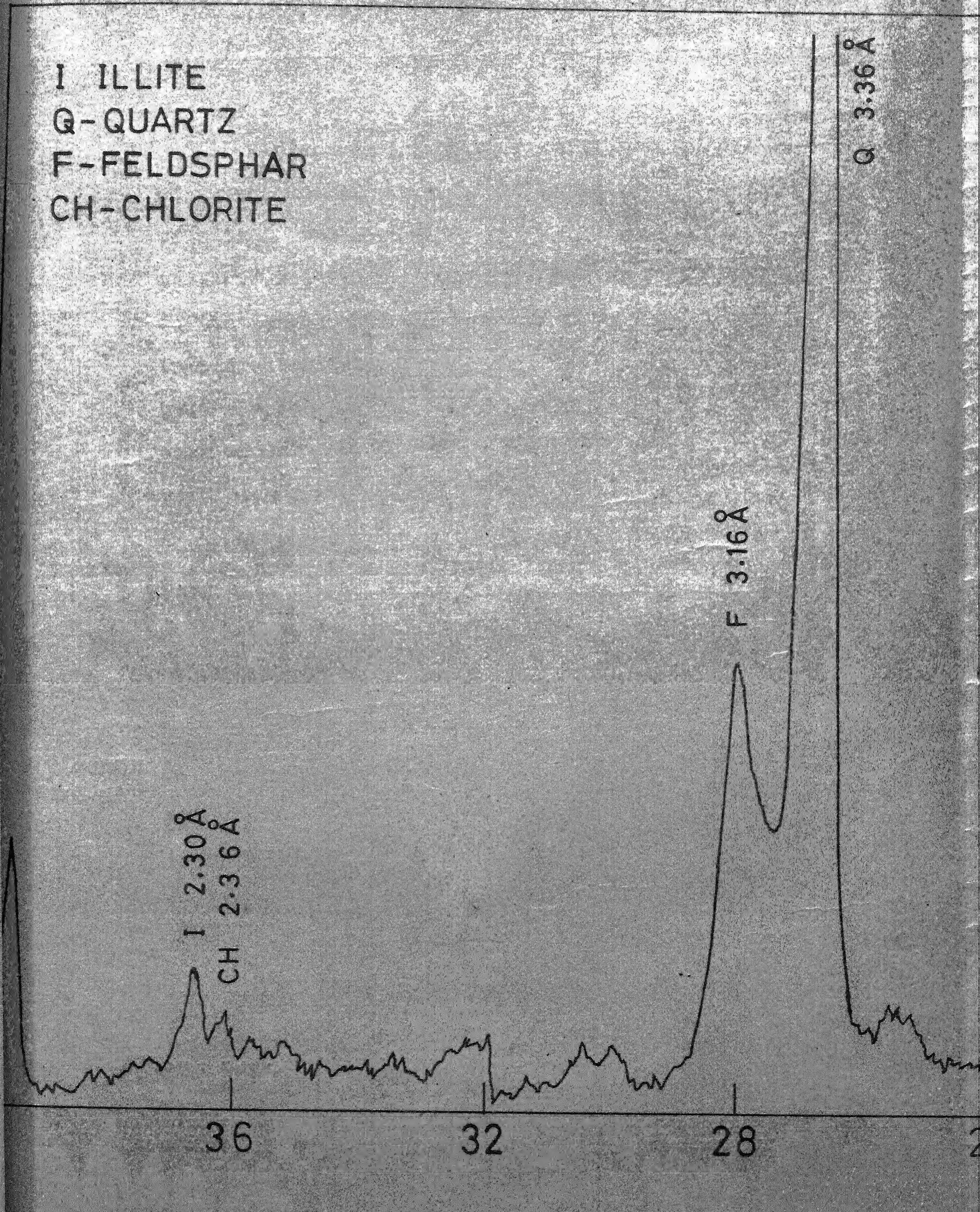
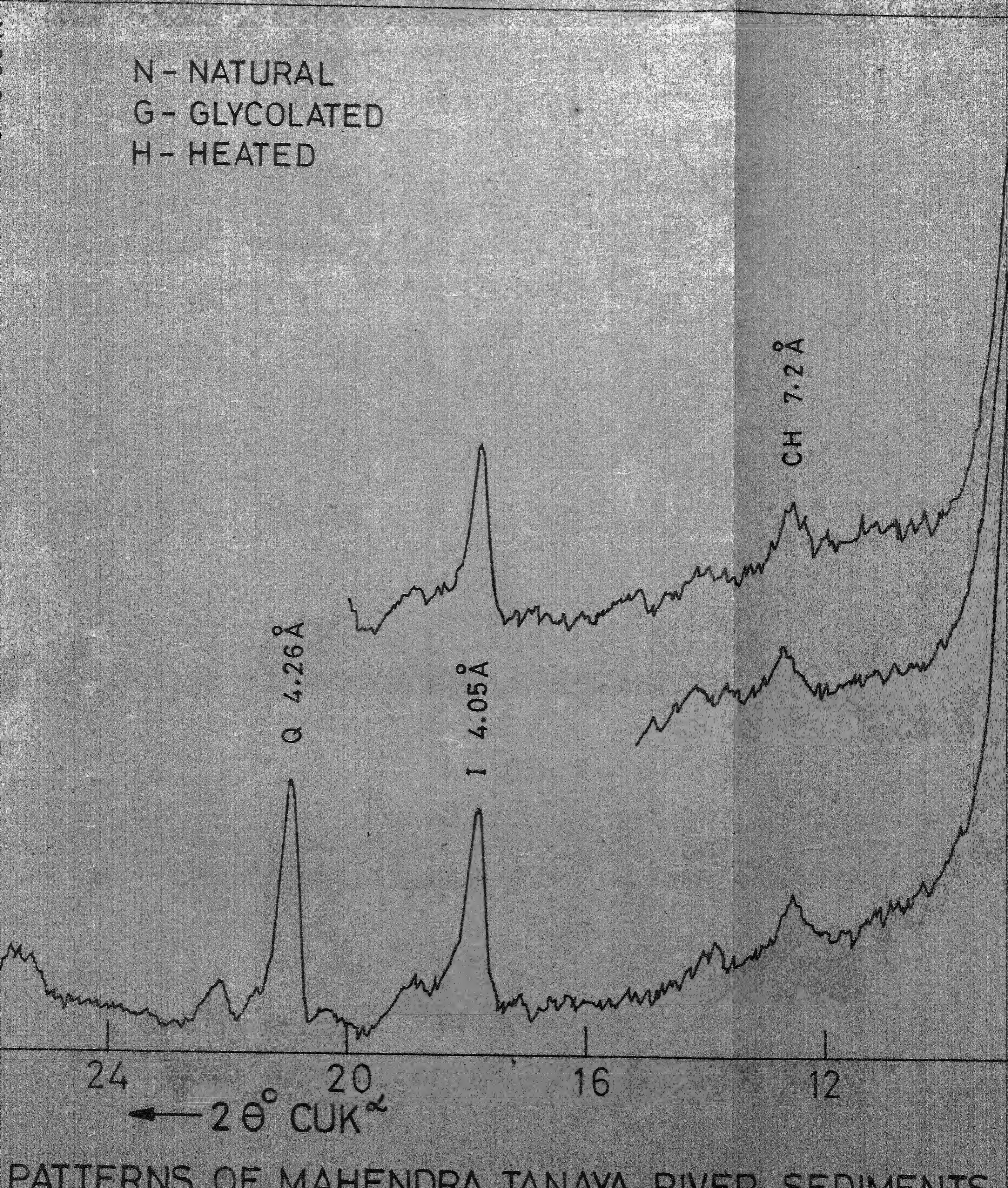
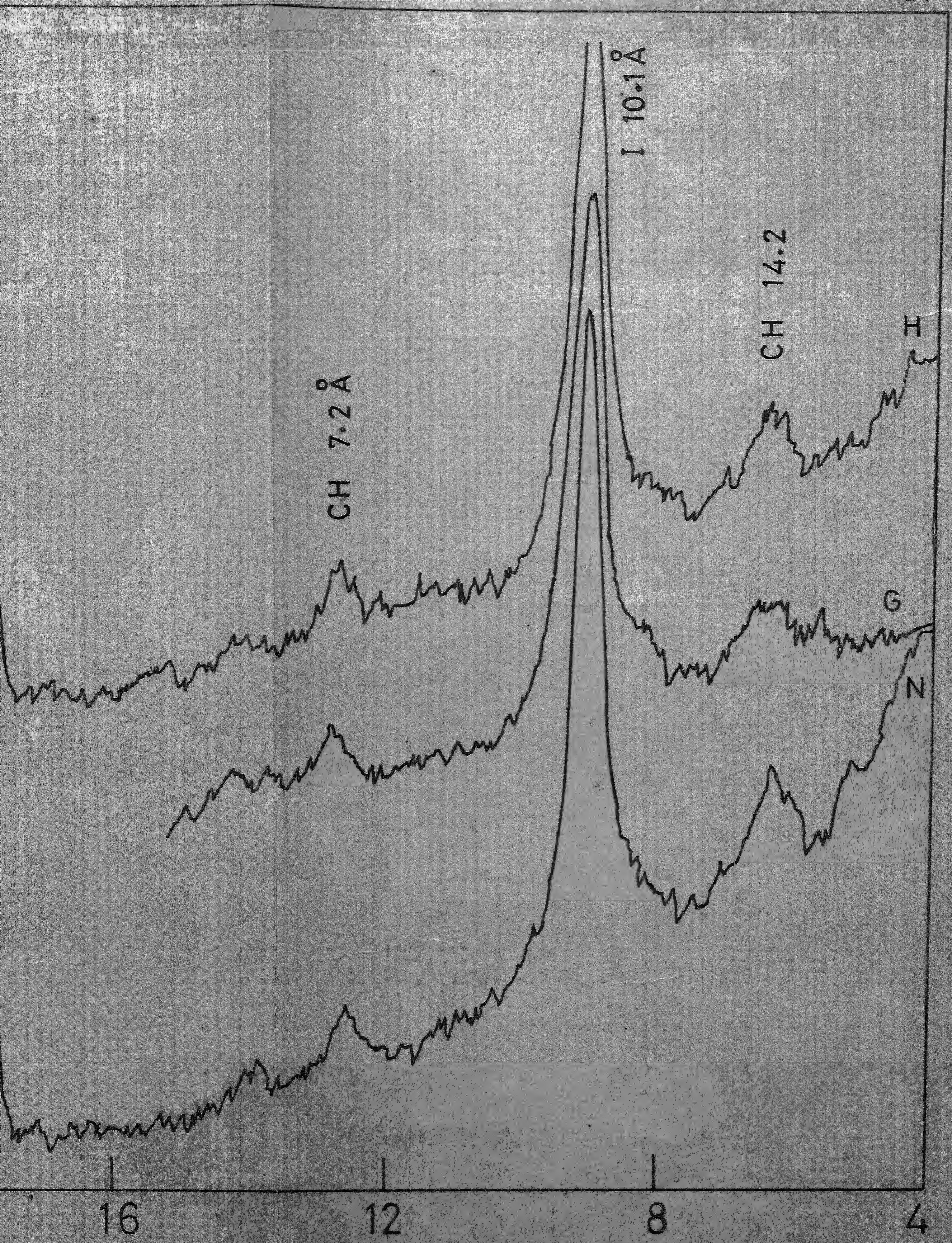


FIG. 4.4 X-RAY DIFFRACTION PATT



PATTERNS OF MAHENDRA TANAYA RIVER SEDIMENTS



TANAYA RIVER SEDIMENTS (CS 10)

Differential thermal analysis reveals the presence of an endothermic peak at 110°C which is caused by the loss of water. The exothermic peak at 310°C is due to organic matter. The 190°C endothermic peak is recognized as due to montmorillonite and the endothermic peak around 320°C is characteristic of gibbsite. Kaolinite is identified by the appearence of 600°C endothermic and an exothermic peak around 1000°C. Illite is identified by endothermic peak around 820°C (Fig. 4.5 and 4.6).

Electron microscopy confirmed the presence of kaolinite by its Psuedo-hexagonal plate shaped crystal appearance (Plate 4.1). Another well developed crystal is recognized as dickite (Plate 4.2).

Station 2 (CS2): At Tumbakota the presence of kaolinite, illite and montmorillonite is noticed. The absence of gibbsite is also confirmed. It is also very interesting to note the appearance of partially dehydrated halloysite (7.6A°).

Differential thermal analysis reveals the presence of kaolinite, illite and montmorillonite. However, for halloysite the characteristic peak around 300°C is not noticed since the halloysite is partially dehydrated.

On the other hand Electron microscopy revealed the characteristic tubular shape of halloysite (Plate 4.3).

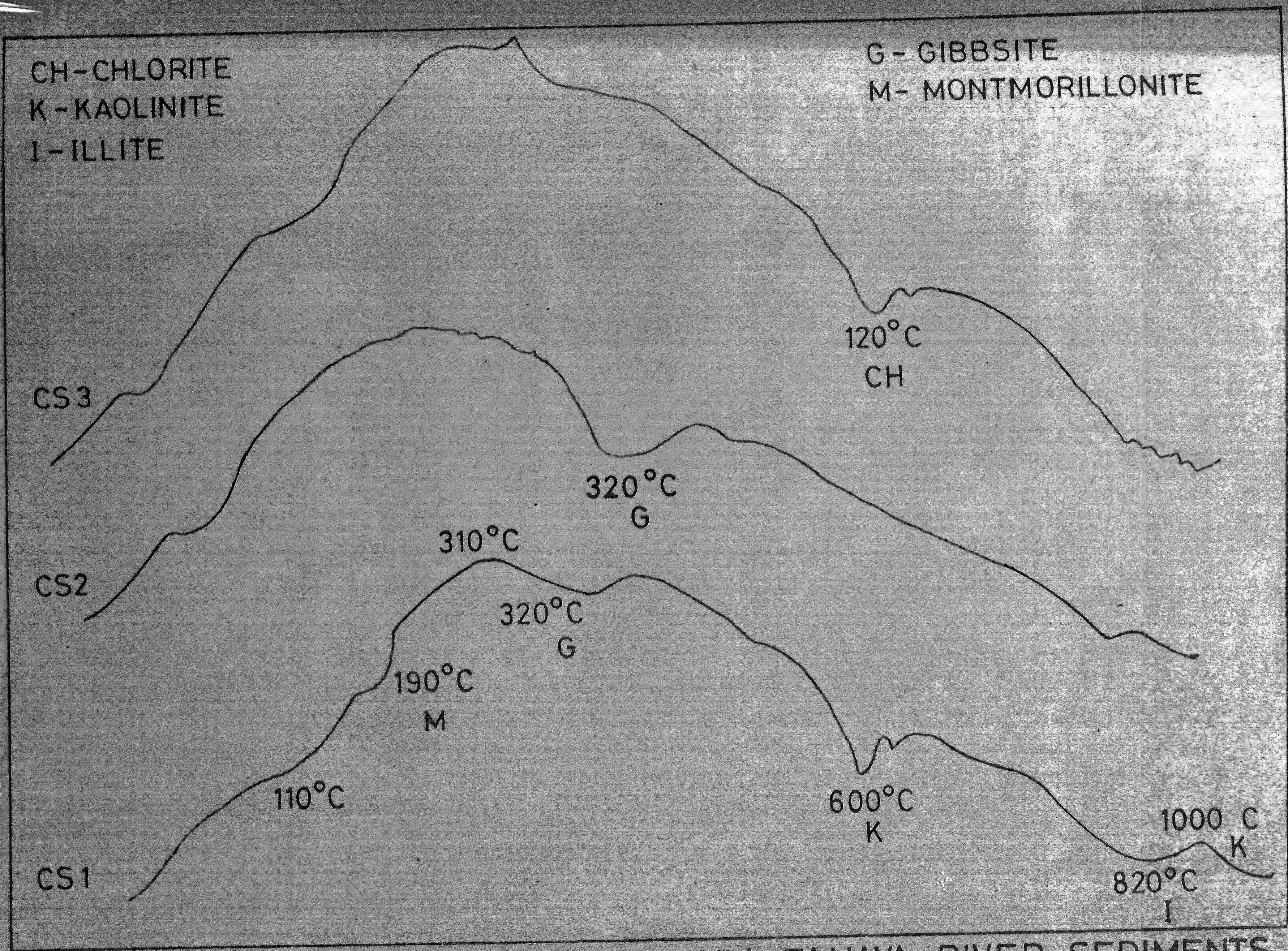


FIG.4.5 D.T.A PATTERNS OF MAHENDRA TANAYA RIVER SEDIMENTS

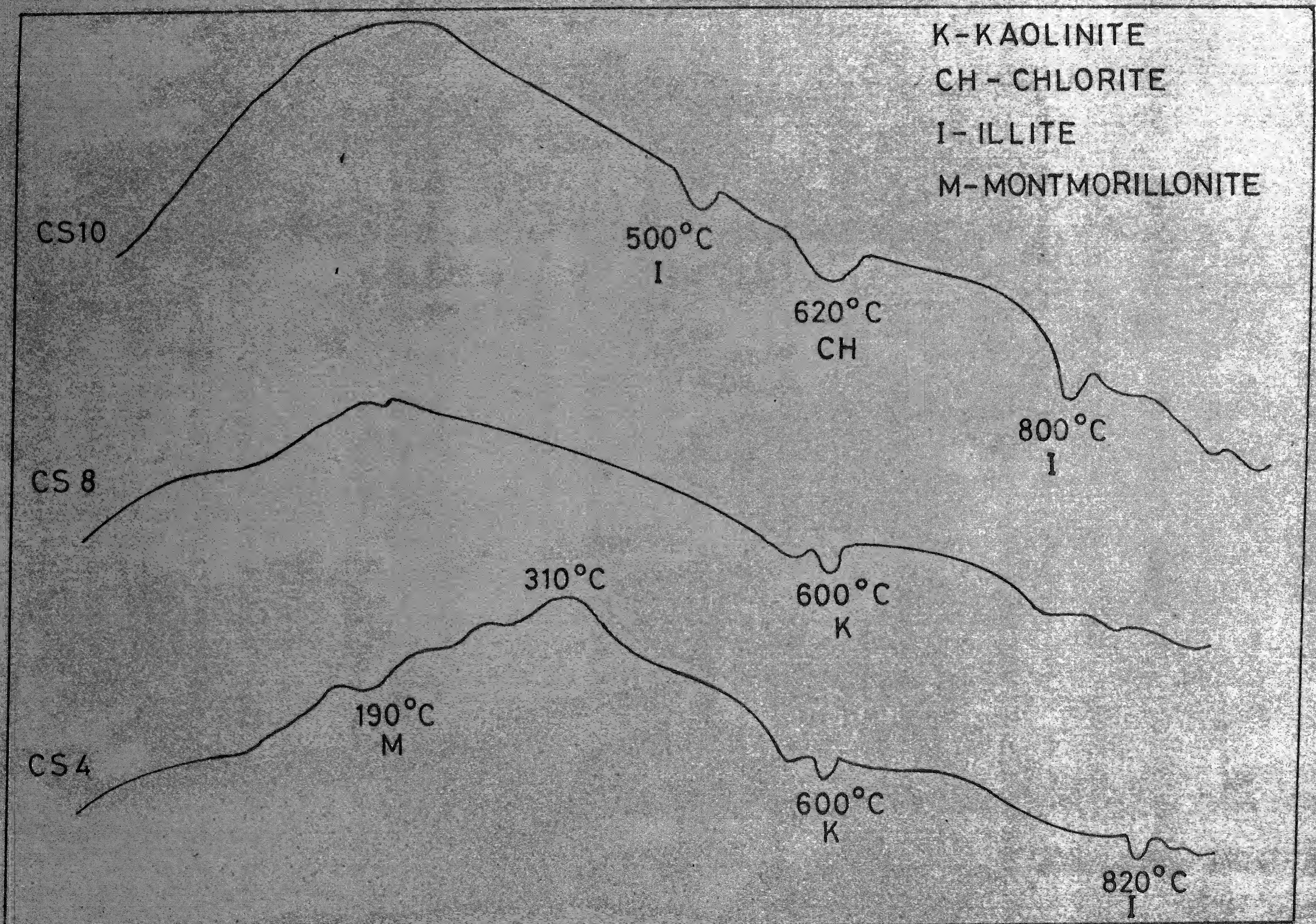


FIG. 4.6 D.T.A PATTERNS OF MAHENDRA TANAYA RIVER SEDIMENTS

Some halloysite tubes from this region show colour zoning (Plate 4.4).

<u>Station 3 (CS3):</u> Around Paidigam, halloysite is not indicated but chlorite is inferred from its 14.4A° basal peak.

Differential thermal analysis confirms the chlorite by the presence of 620°C endothermic peak.

Electron micrograph has shown a distinct crystal (Plate 4.5) identified as chlorite. Another chlorite crystal is recognized (Plate 4.6) in which it is formed from authigenesis.

<u>Station 4 (CS4):</u> At Bhogapuram, except the increase of illite and slight decrease of kaolinite the clay mineralogy seems to be same.

<u>Station 5 (CS5):</u> At Pottangi intensities of peaks of kaolinite decreases and intensities of illite, chlorite peaks increases. Montmorillonite seems to persist even at this locality.

<u>Station 6 (CS6):</u> The sample from Patra Konda shows clay mineralogy identical with the upstream sample CS5.

<u>Plain stretch:</u> (Kothapuram - Wadapalem).

<u>Station 7 (CS7):</u> At Kothapuram, sample shows kaolinite, illite and mixed layer of montmorillonite-chlorite.

Station 8 (CS8): At Turaka sasanam, the clay minerals identified are kaolinite, illite and montmorillonite chlorite mixed layer.

Differential thermal analysis has also revealed the presence of above mineralogy.

Station 9 (CS9): At Wadapalem, a complete disappearance of kaolinite and montmorillonite has been noticed. At the same time illite has been observed to be the dominant clay mineral with an association of chlorite.

Station 10 (CS10): At river-sea confluence shows the presence of illite and chlorite. Montmorillonite is not even seen after glycolation (Fig. 4.4).

Differential thermal analysis indicate the presence of 500°C and 800°C endothermic peaks for illite. The endothermic peak around 620°C indicates the presence of chlorite which is also confirmed from the X-ray data.

Electron micrographs have revealed flakes of mica (Plate 4.7).

Conclusions: On the basis of this comprehensive record of the type of clay minerals present in the river sediment from source to mouth, an attempt was made to quantify the data in terms of relative abundance. It was assumed that

relative intensities of X-ray diffraction peaks approximately represents relative proportion of minerals in a mixture, on this basis Table 4.1 is prepared showing peak heights of the (001) basal reflections of major clay minerals at each station. The variation of relative abundence is further enhanced by considering the ratio of peak heights between kaolinite and illite. This mineral pair is selected because existing literature commonly suggests conversion of kaolinite to illite during diagenetic reactions (Weaver , 1967).

It is easy to identify the following trends from Table 4.1. It is obvious that sediments near the source of the river CS1 contains kaolinite and montmorillonite as the dominent clay minerlas. These minerals come to the river as products of chemical weathering of the parent rocks. Previous work has indicated (Krauskopf, 1967) that kaolinite is the common weathering product of granitic rocks in well-drained slopes. Montmorillonite, on the other hand, forms when the primary rock is Fe, Mg rich (e.g. Charnockite) and drainage is poor. In the Mahendra Tanaya river basin, kaolinite can come from granite gneiss, quartzite, khondlite and laterite where as montmorillonite may have been derived from leptynite and charnockite.

TABLE 4.1 BASAL (001) REFLECTIONS OF THE CLAY MINERALS

Sample No. (From source to mouth)	K	I	M	CH	K/I
1	18	5	15	0	3.60
2	5	2	2	0	2.50
3	5	2	10	1	2.50
4	7	20	3	1	0.35
5	4	5	3	1	0.80
6	4	8	3	1	0.50
7	3	15	3	1	0.20
8	1	15	3	1	0.06
9	1	20	1	2	0.05
10	0	80	0	8	0.00

Near the mouth of the river CS10 both kaolinite and montmorillonite completely disappear. It is apparent that illite and chlorite grown on the expense of these two minerals. The high salt content of the river at the mouth almost surely results in a reaction of the type kaolinite $+ K^{+} =$ illite $+ H^{+}$ and the kaolinite/illite ratio continuous decrease from station 1 to station 10 confirming that such a reaction takes place along the course of the river from source to mouth.

The growth of chlorite towards the river mouth is more drastic. This mineral is absent upto station 3. The chlorite/kaolinite ratio is 1/7 to 1/3 between station 1 and 7. At the same stretch the chlorite/montmorillonite ratio is 1/3. The ratio increase to 2:1 at station 9 until kaolinite and montmorillonite disappear at the river mouth. It is possible chlorite grows by a reaction of the type.

$$\text{Kaolinite or montmorillonite} + Fe^{++} + Mg^{++} \rightarrow \text{Chlorite.}$$

Similar increase of illite and chlorite at the expense of montmorillonite has been reported from the gulf of Mexico and illustrated by Stumm and Morgan (1970).

CHAPTER V

HEAVY MINERAL ANALYSIS

Heavy minerals have been separated from soil samples by using bromoform, then they mounted up on glass slides to their mineralogical study. Polarizing microscope is a reliable method to evaluate the percentages of heavy mineral suits of suspended river sediments. Infact, indentification of heavy minerals are also attempted by X-ray diffraction technique. Standard procedures are followed up for identification of heavy minerals.

In general, sillimanite, garnet, hypersthene, muscovite, rutile, magnetite, ilmenite, zireon, monazite were identified.

Sillimanite: It was identified by its prismatic form, high relief and parallel extinction.

Garnet: It was identified by its pink colour under polarized light, high relief and isotropic form.

Hypersthene: It's identification is followed by its green colour, flattened form and prismatic cleavage with parallel extinction.

Muscovite: It was identified by its flaky form and basal cleavage and low relief.

Rutile; It was identified by its reddish brown colour, prismatic form, high relief and parallel extinction.

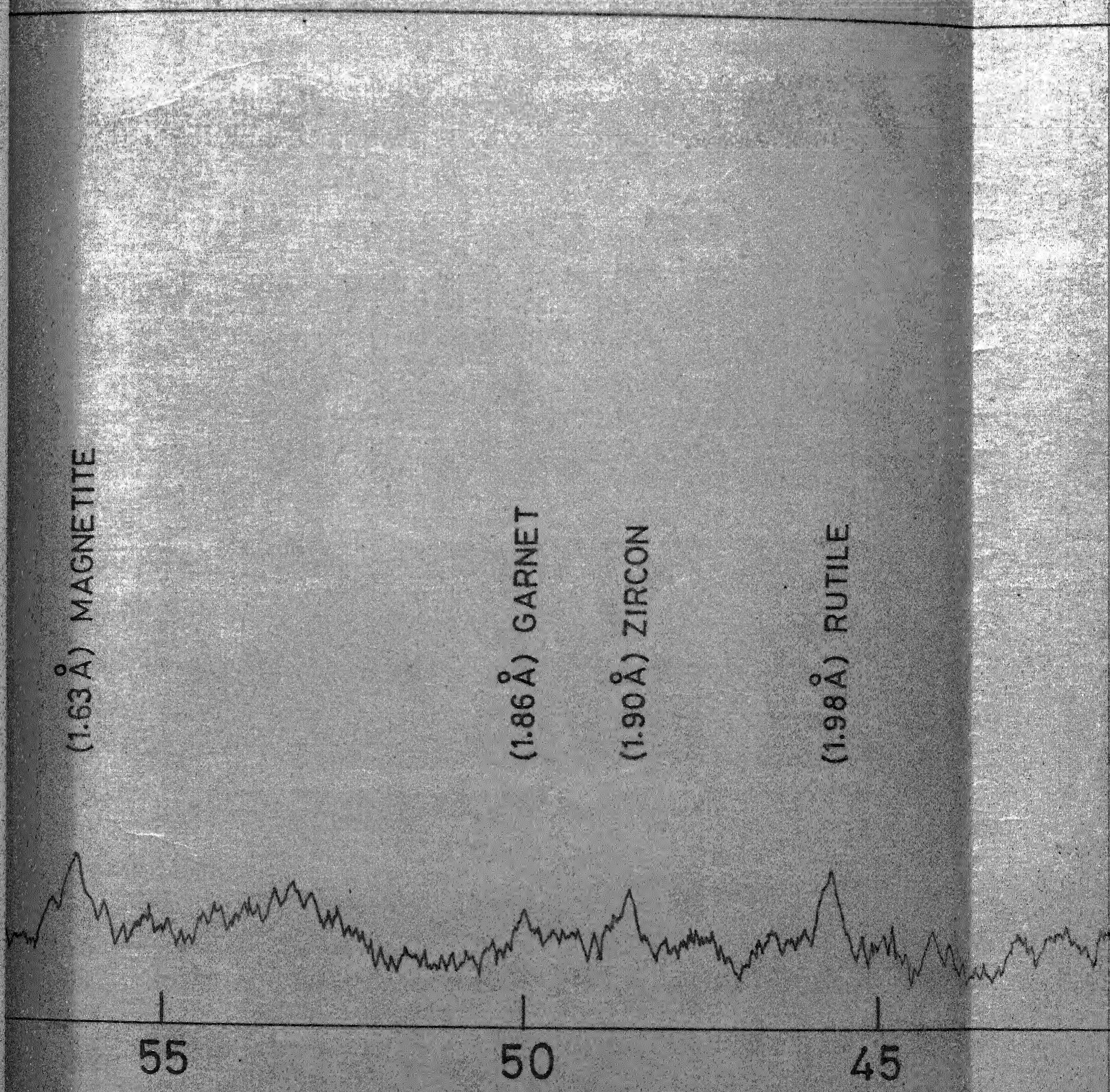
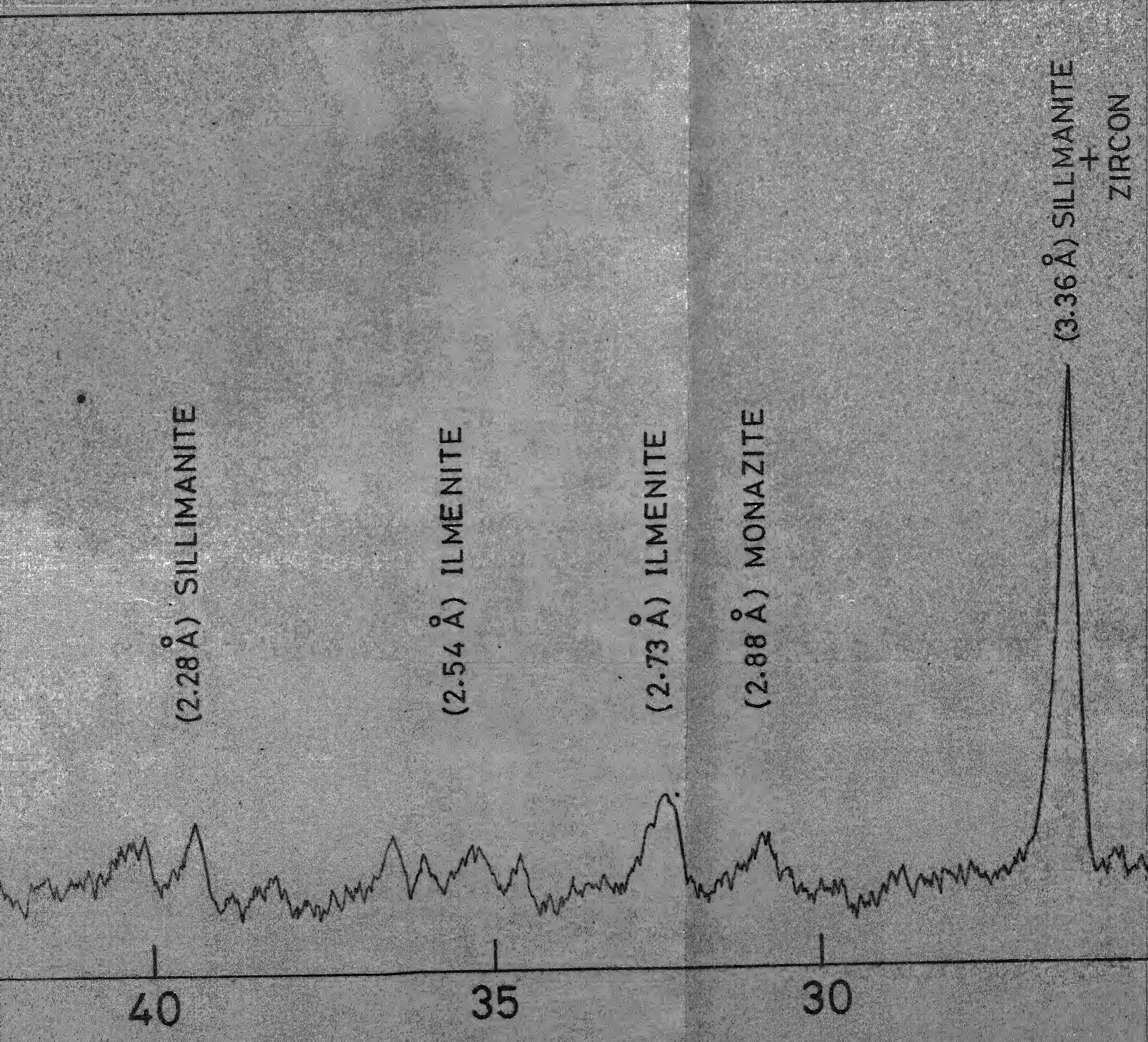
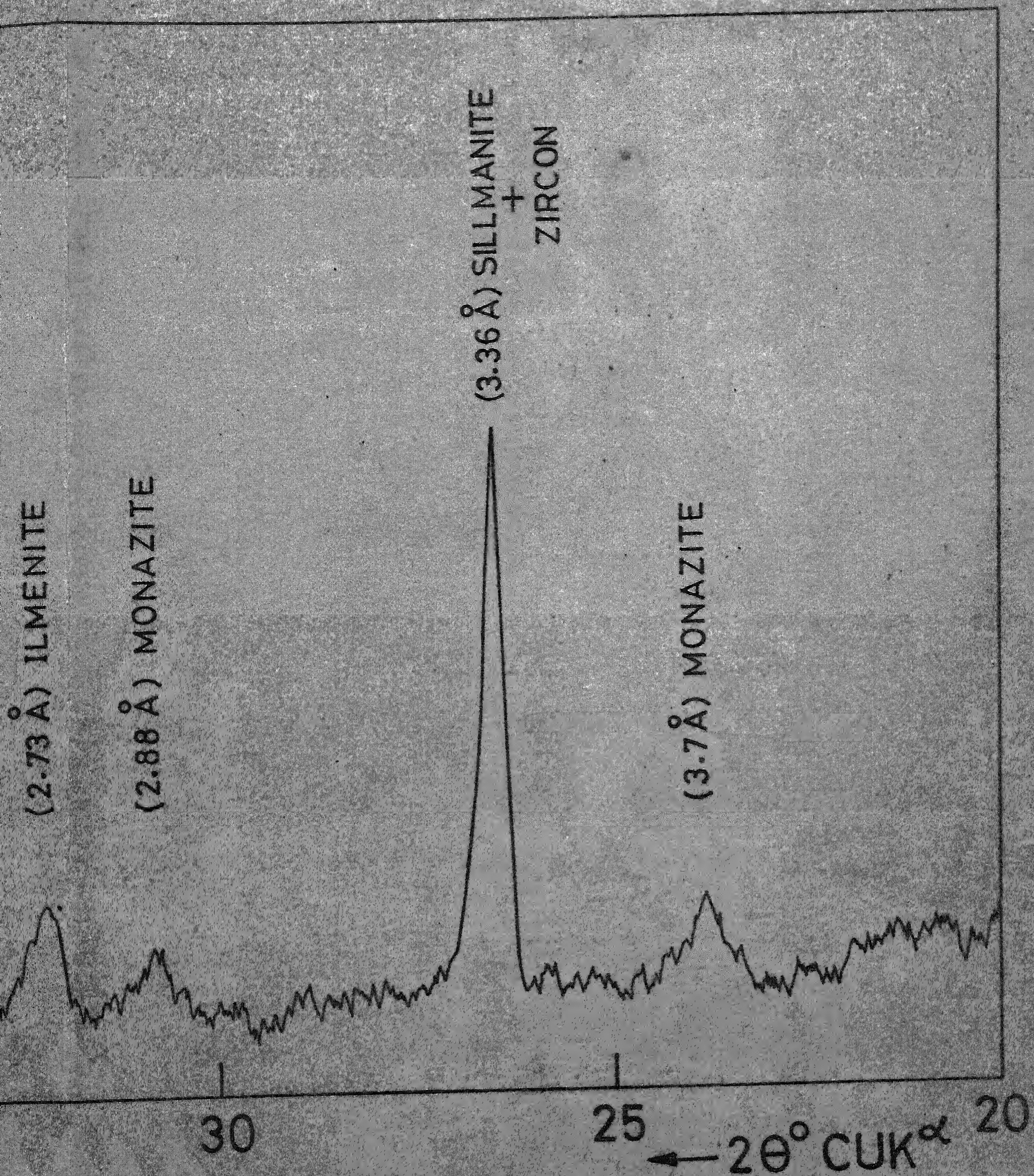


FIG. 5.2 X-RAY DIFFRACTION PATTER



ERN OF MAHENDRA TANAYA RIVER SEDIMENTS (Hs



RIVER SEDIMENTS (Hs10)

TABLE 4.3 HEAVY MINERAL PERCENTAGES OF MAHENDRA TANAYA RIVER SEDIMENTS

Name of the Minerals	Sample Number									
	1	2	3	4	5	6	7	8	9	10
Garnet	20	25	15	35	40	38	26	20	25	26
Hypersthene	15	10	5	15	20	23	16	10	9	12
Sillimanite	40	38	55	21	4.0	16.8	36	34	42	28
Muscovite	20	17	8	5	3.0	-	6	15	-	-
Ilmenite	-	-	-	3.0	4.0	4.3	2	6	10	9
Rutile	3.0	5.0	8.0	9.0	6.0	8.4	6.0	4.0	3.0	4.0
Magnetite	2.0	3.0	5.0	7.0	9.0	6.5	3.0	7.0	6.0	10.0
Zircon	-	2.0	4.0	5.0	4.0	3.0	5.0	4.0	5.0	8.0
Monazite	-	-	-	-	-	-	-	-	-	3.0

FIG. 5.3 HISTOGRAMS OF HEAVY MINERALS FROM MAHENDRA TANAYA RIVER SEDIMENTS

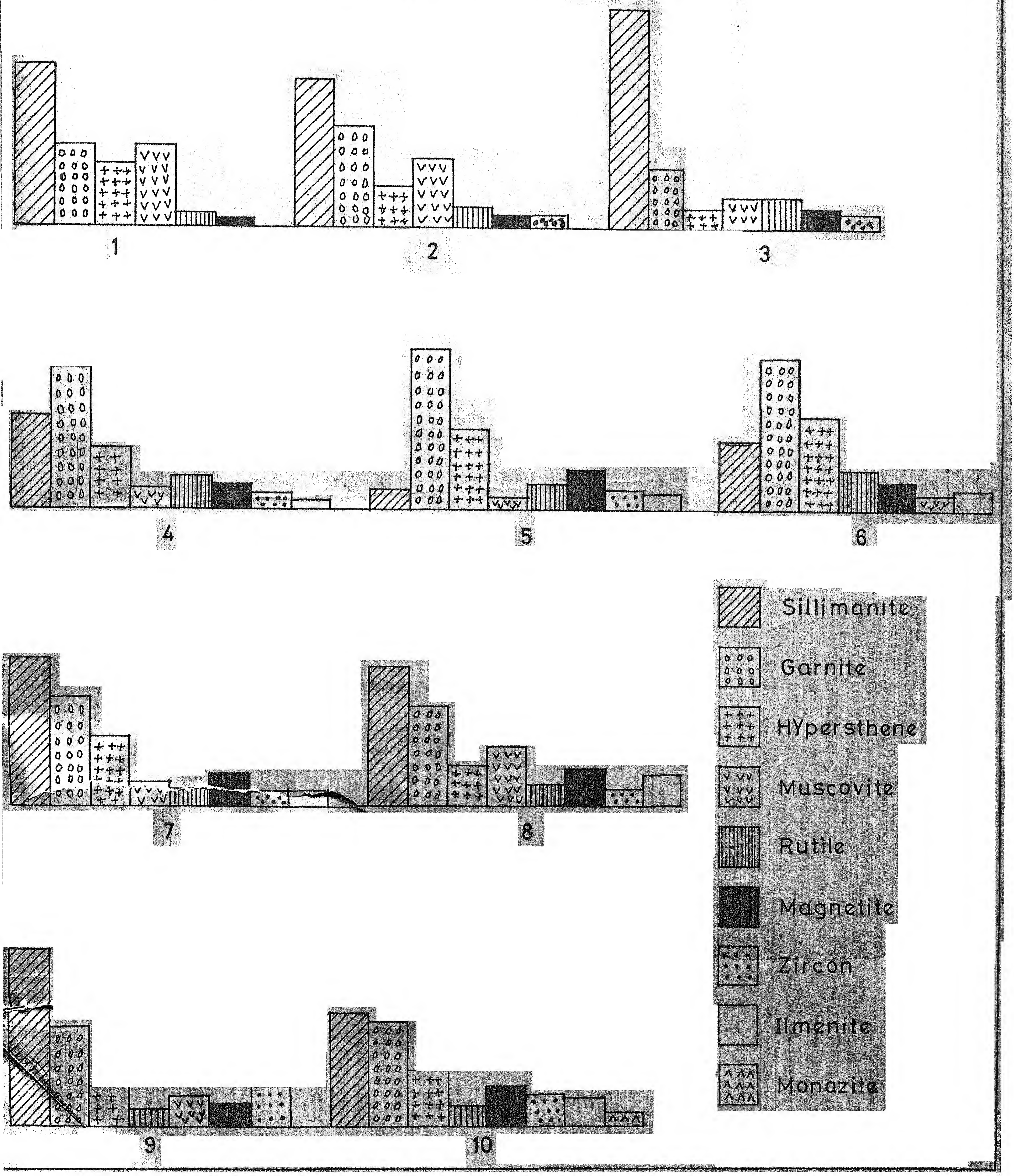


Plate 5.1

Heavy Mineral Residues from River Sediment
Under Polarized light X 25

Location : Kothapuram

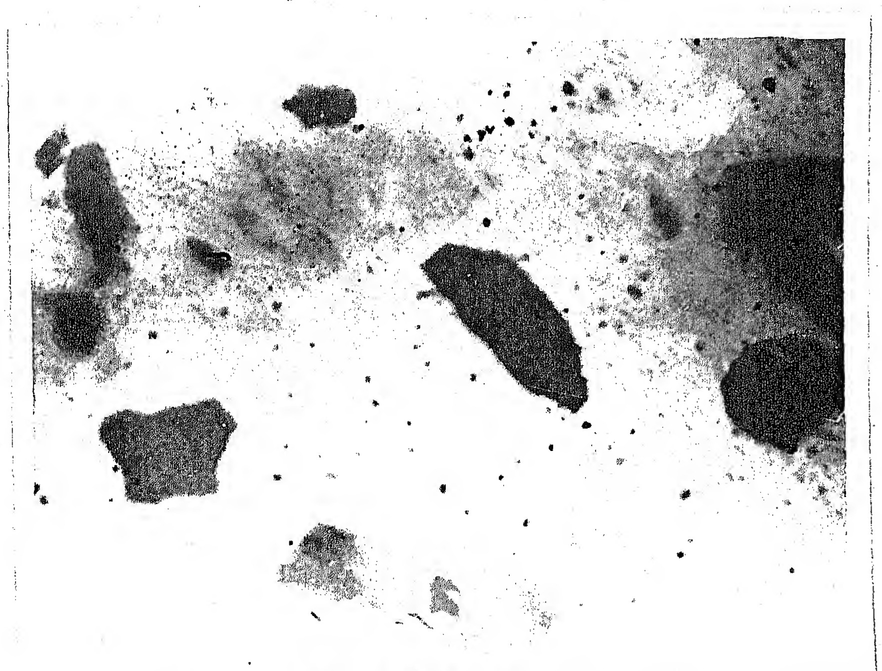


Plate 5.2 Heavy Mineral Residues from Estuary Sediments
Under Crossed Nichols X 25
Location : River-sea Junction)

for minerals is followed by their characteristic peak intensities.

River-sea Confluence (HS10): The same minerals found as in Wadapalem and also monazite is observed and confirmed by X-raydiffraction Patterns (Fig. 5.2). Plate 5.2 shows the mineral assemblage found in this region.

Conclusions: To demonstrate the heavy mineral variation at each locality, the proportions of index minerals is shown in Table 5.1 and Fig. 5.3. The variation is correlated with the possible source. The minerals are detrital in the sense that they are residue from weathering of the source rock and are transported to the river basin.

The increase of garnet and decrease of sillimanite towards estuary is due to availability of garnetiferrous leptynites. The abundane of sillimanite in the upper stretch is controlled by sillimanite gneiss (Khondalite). The sudden presence of monazite in HS10 indicates it is derived from mixing of long-shore drift.

CHAPTER VI

SYNTHESIS

The Mahendra Tanaya river has a medium-sized watershed located between $84^{o}19'22''$E, $84^{o}32'$E longitudes and $18^{o}51'30''$ N, $19^{o}2'55''$ N latitude. The 37 km length of the river can be divided into two stretches: an upper (hilly) stretch and a lower (plain) stretch. The river originates at Mahendra Giri (1475 m) in Orissa state and meets the sea near Baruva, Andhra Pradesh. Therefore a sharp decrease in elevation from source to mouth.

The upper part of the river basin is comprised by a variety of rock types namely, Khondallite, Charnockite, Leptynite and Granite Gneiss. There is also a pronounced laterite capping on the country rocks. The lower part is covered by recent alluvium.

Under a humid tropical climate, the rocks in the river basin undergo mechanical and chemical weathering. Mechanical weathering desintegrates the rock and the mineral grains resistant to weathering contribute to the suspended load of the weathering. The heavy minerals like garnet, sillimanite, zircon, rutile, magnetite and hypersthene belong to this category. Their occurrence and variation along the river course has been correlated

with the characteristic source rock in the vicinity. For example, garnet and sillimanite are derived from Khondalite, hypersthene from Charnockite and so on. Near the mouth, monazite sand carried by ocean current apparently mixes with river sediments.

In contrast with mechanical (physical) weathering, chemical weathering of rocks results in two types of products. One is the group of clay minerals which also adds to suspended load. The other are the chemical constituent released from the rocks which add to the dissolved load of the river. In the Mahendra Tanaya basin, the upper part contains kaolinite and montmorillonite as dominant clay minerals in the river sediments. They are obviously derived from laterites and more recently weathered rocks. During the transport in river water, there is a chemical reaction between fine grained clays and river water. This is basically a potassium ion uptake resulting in the conversion of kaolinite and montmorillonite to illite. This has been confirmed by studying the increase in relative proportion of illite from source to mouth with complete dissappearance of montmorillonite near mouth. Chlorite proportion also increases probably by similar uptake of Mg and Fe ions.

This study has thus demonstrated that the mineralogy of a river sediment depends on (1) type of rocks present in the drainage basin, (2) nature and extent of weathering and (3) mutual reaction between suspended load and river water. The variation in mineralogy along the river controls the mineral composition and various properties of alluvium deposited by rivers. A more detailed study of this process would obviously applicable to engineering and agriculture utilization of alluvial soils. For example, the strength parameters and cation exchange capacity of soils are known to be sensitive to mineralogy.

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